D E C L A R A T I O N

In the matter of U.S. Patent Application Ser. No. 09/886,213 in the name of Yuji MATSUYAMA et al.

I, Kumi HIRANO, of Kyowa Patent and Law Office, 2-3, Marunouchi 3-Chome, Chiyoda-Ku, Tokyo-To, Japan, declare and say:

that I am thoroughly conversant with both the Japanese and English languages; and,

that the attached document represents a true English translation of Japanese Patent Application No. 1998-322884 filed on October 28, 1998.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Kumi HIRANO

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[Title of Invention] HEAT TREATMENT METHOD, HEAT TREATMENT APPARATUS AND TREATMENT SYSTEM

[Claims]

[Claim 1]

A method to heat-treat a substrate coated with a coating solution which oxidizes at high temperatures, said method comprising the step of:

heat-treating the substrate in the heat treatment atmosphere of which the gas concentration is controlled.

[Claim 2]

A method to heat-treat a substrate coated with a coating solution which oxidizes at high temperatures, said method comprising the steps of:

lowering an oxygen concentration of a treatment atmosphere when the temperature is low;

heat-treating the substrate in the treatment atmosphere of which the oxygen concentration is lowered; and

returning the treatment atmosphere to that with the original oxygen concentration after the passage of a predetermined time from the completion of said heat treatment.

[Claim 3]

A method to heat-treat a substrate coated with an organic coating solution, said method comprising the steps of:

replacing the treatment atmosphere with inert gas when the temperature is low;

heat-treating said substrate in the treatment atmosphere of the replaced inert gas; and

exposing the treatment atmosphere to the air after the passage of a predetermined time from the completion of the heat treatment.

[Claim 4]

A method to heat-treat a substrate coated with a solution which oxidizes at high

temperatures, said method comprising the steps of:

lowering an oxygen concentration of the treatment atmosphere when the temperature is low;

heat-treating said substrate in the treatment atmosphere with the lowered oxygen concentration; and

returning the treatment atmosphere to that with the original oxygen concentration when the temperature of the substrate becomes lower than a predetermined value.

[Claim 5]

A method to heat-treat a substrate coated with an organic coating solution, said method comprising the steps of:

replacing the treatment atmosphere with inert gas when the temperature is low;

heat-treating the substrate in the treatment atmosphere of the replaced inert gas; and

exposing the treatment atmosphere to the air when the temperature of the substrate becomes lower than a predetermined value.

[Claim 6]

A heat treatment apparatus, comprising:

a treatment chamber;

a holding member provided in said treatment chamber for holding a substrate coated with an organic coating solution;

a means for replacing an atmosphere in said treatment chamber with inert gas;

a means for heat-treating the substrate held by said holding member in the atmosphere which is replaced with the inert gas by said replacing means; and

a means for exposing the inside of said treatment chamber to the air after the passage of a predetermined time from the completion of the heat treatment.

[Claim 7]

A heat treatment apparatus, comprising:

a treatment chamber having a lid body which opens and closes;

a holding and heating member provided in said treatment chamber for holding and heating a substrate coated with an organic coating solution;

support pins appearing and disappearing from/into a surface of said holding and

heating member for supporting the substrate apart from the surface of said holding and heating member when appearing and for mounting the substrate on the surface of said holding and heating member when disappearing;

a means for replacing an atmosphere in said treatment chamber with inert gas while the substrate is mounted on said support pins;

a means for heat-treating the substrate, which is mounted on the surface of said holding and heating member as a result of said support pins disappearing, in the atmosphere which is replaced with the inert gas by said replacing means; and

a means for separating the substrate from the surface of said holding and heating member by projecting said support pins after completing the heat treatment and opens the lid body to expose the inside of said treatment chamber to the air after the passage of a predetermined time.

[Claim 8]

The heat treatment apparatus as set forth in claim 6 or 7,

wherein said replacing means includes a means for blowing inert gas into said treatment chamber.

[Claim 9]

The heat treatment apparatus as set forth in claim 8,

wherein the blowout of inert gas by said blowing means is controlled in accordance with the passage of a treatment time.

[Claim 10]

A heat treatment apparatus, comprising:

a treatment chamber;

a holding member provided in said treatment chamber for holding a substrate coated with an organic coating solution;

a means for replacing an atmosphere in said treatment chamber with inert gas;

a means for heat-treating the substrate held by said holding member in the atmosphere which is replaced with the inert gas by said replacing means;

a means for measuring the temperature of the substrate to be heat-treated; and

a means for exposing the inside of said treatment chamber to the air when the

temperature of the substrate becomes lower than a predetermined value after completing the heat treatment.

[Claim 11]

A heat treatment apparatus, comprising:

a treatment chamber having a lid body which opens and closes;

a holding and heating member provided in said treatment chamber for holding and heating a substrate coated with an organic coating solution;

support pins appearing and disappearing from/into a surface of said holding and heating member for supporting the substrate apart from the surface of said holding and heating member when appearing and for mounting the substrate on the surface of said holding and heating member when disappearing;

a means for replacing an atmosphere in said treatment chamber while the substrate is mounted on said support pins;

a means for heat-treating the substrate, which is mounted on the surface of said holding and heating member as a result of said support pins disappearing, in the atmosphere which is replaced with the inert gas by said replacing means; and

a means for measuring the temperature of the substrate to be heat-treated; and

a means for separating the substrate from the surface of said holding and heating member by projecting said support pins after completing the heat treatment and opens the lid body to expose the inside of said treatment chamber to the air when the temperature of the substrate becomes lower than a predetermined value.

[Claim 12]

The heat treatment apparatus as set forth in claim 10 or 11,

wherein said replacing means includes a means for blowing inert gas into said treatment chamber.

[Claim 13]

The heat treatment apparatus as set forth in claim 12,

wherein the blowout of inert gas by said blowing means is controlled in accordance with the temperature of the substrate.

[Claim 14]

A treatment system, comprising:

the heat treatment apparatus as set forth in any one of claims 6 to 13; and

a carrying apparatus disposed in said treatment chamber containing inert gas atmosphere for carrying the substrate in/out,

wherein said carrying apparatus includes a holding and cooling plate for holding and cooling the substrate, and adjusting and supporting pins disposed adjustably in height on the holding and cooling plate for supporting the substrate to be apart from the holding and cooling plate.

[Background of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a heat treatment method, a heat treatment apparatus and a treatment system useful, for example, for forming an SOD (Spin On Dielectric) film on a semiconductor wafer.

[0002]

[Description of the Related Art]

When forming an organic SOD film such as plastic on a semiconductor wafer (referred to as "a wafer" hereinafter), the process is generally carried out as described below.

[0003]

First, while the wafer mounted on a spin chuck is rotated, a coating solution is supplied onto a rotational center of the wafer. Thereby, the supplied coating solution is spread out on the whole surface of the wafer by centrifugal force. Next, the wafer coated with the coating solution is heat-treated, for example, at about 400℃ in an oven. Thereafter, the wafer is carried to a cooling treatment apparatus by a carrying apparatus to be cooled by the cooling treatment apparatus.

[0004]

[Problems to be Solved by the Invention]

However, when the coating solution is organic such as plastic, there is a

disadvantage that the heat treatment at high temperature as described above causes the coating solution on the substrate to oxidize. Further, a fine adjustment for performing an appropriate cooling is difficult when the substrate is cooled from the high temperature as described above.

[0005]

The present invention was made to solve the above problems and an object thereof is to provide a heat treatment method, a heat treatment apparatus and a treatment system capable of heat-treating a substrate, controlling the oxidization of a coated solution. Another object of the present invention is to provide a treatment system in which a fine adjustment for performing an appropriate cooling is easy and also the mechanism is simple.

[0006]

[Means for Solving the Problems]

To solve the above problems, the present invention provides a heat treatment method for heat-treating a substrate coated with a coating solution which oxidizes at high temperatures, wherein the concentration of a gas in a heat treatment atmosphere is controlled when the substrate is heat-treated.

[0007]

The heat treatment method of the present invention for heat-treating a substrate coated with a coating solution which oxidizes at high temperatures includes the processes of: lowering an oxygen concentration of a treatment atmosphere when the temperature is low; heat-treating the substrate in the treatment atmosphere of which the oxygen concentration is lowered; and returning the treatment atmosphere to that with the original oxygen concentration after completing the heat treatment.

[0008]

In the heat treatment method of the present invention for heat-treating a substrate coated with an organic coating solution includes the processes of: replacing a treatment atmosphere with inert gas when the temperature is low; heat-treating the substrate in the treatment atmosphere of the replaced inert; and exposing the treatment atmosphere to the air after the passage of a predetermined time from the completion of the heat treatment.

[0009]

The heat treatment method of the present invention for heat-processing a substrate coated with a coating solution which oxidizes at high temperatures includes the processes of: lowering an oxygen concentration of a treatment atmosphere; heat-treating the substrate in the treatment atmosphere of which the oxygen concentration is lowered; and returning the treatment atmosphere to that with the original oxygen concentration after the passage of a predetermined time from the completion of said heat treatment.

[0010]

The heat treatment method of the present invention for heat-treating a substrate coated with an organic coating solution includes the processes of: replacing a treatment atmosphere with inert gas when the temperature is low; heat-treating the substrate in the treatment atmosphere of the replaced inert gas; exposing the treatment atmosphere to the air when the temperature of the substrate becomes lower than a predetermined value.

[0011]

A heat treatment apparatus of the present invention includes: a treatment chamber; a holding member provided in the treatment chamber for holding the substrate coated with an organic coating solution; a means for replacing an atmosphere in the treatment chamber with inert gas; a means for heat-treating the substrate held by the holding member in the atmosphere which is replaced with the inert gas by the replacing means; and a means for exposing the inside of the treatment chamber to the air after the passage of a predetermined time from the completion of the heat treatment.

[0012]

The heat-treatment apparatus of the present invention includes: a treatment chamber having a lid body which opens and closes; a holding and heating member provided in the treatment chamber for holding and heating a substrate coated with an organic coating solution; support pins appearing and disappearing from/into a surface of the holding and heating member for supporting the substrate apart from the surface of the holding and heating member when appearing and for mounting the substrate on the surface of the holding and heating member when disappearing; a means for replacing an atmosphere in the treatment chamber while the substrate is mounted on the support pins; a means for

heat-treating the substrate, which is mounted on the surface of the holding and heating member as a result of the support pins disappearing, in the atmosphere which is replaced with the inert gas by the replacing means; and a means for separating the substrate from the surface of the holding and heating member by projecting the support pins after completing the heat treatment and opens the lid body to expose the inside of the treatment chamber to the air after the passage of a predetermined time.

[0013]

The heat treatment apparatus of the present invention is the heat treatment apparatus as described above of which the replacing means includes a means for glowing inert gas into the treatment chamber.

[0014]

The heat treatment apparatus of the present invention is the heat treatment apparatus as described above, wherein the blowout of inert gas by the blowing means is controlled in accordance with the passage of treatment time.

[0015]

The heat treatment apparatus of the present invention includes: a treatment chamber; a holding member provided in the treatment chamber for holding a substrate coated with an organic coating solution; a means for replacing an atmosphere in the treatment chamber with inert gas; a means for heat-treating the substrate held by the holding member in the atmosphere which is replaced with the inert gas by the replacing means; a means for measuring the temperature of the substrate to be heat-treated; and a means for exposing the inside of the treatment chamber to the air when the temperature of the substrate becomes lower than a predetermined value after completing the heat treatment.

[0016]

The heat treatment apparatus of the present invention includes: a treatment chamber having a lid body which opens and closes; a holding and heating member provided in the treatment chamber for holding and heating a substrate coated with an organic coating solution; support pins appearing and disappearing from/into a surface of the holding and heating member for supporting the substrate apart from the surface of the holding and heating member when appearing and for mounting the substrate on the surface of the

holding and heating member when disappearing; a means for replacing an atmosphere in the treatment chamber with inert gas while the substrate is mounted on the support pins; a means for heat-treating the substrate, which is mounted on the surface of the holding and heating member as a result of the support pins disappearing, in the atmosphere which is replaced with the inert gas by the replacing means; a means for heat-treating the substrate, which is mounted on the surface of the holding and heating member as a result of the support pins disappearing, in the atmosphere which is replaced with the inert gas by the replacing means; a means for measuring the temperature of the substrate to be heat-treated; and a means for separating the substrate from the surface of the holding and heating member by projecting the support pins after completing the heat treatment and opens the lid body to expose the inside of the treatment chamber to the air after the passage of a predetermined time.

[0017]

The heat treatment apparatus of the present invention is the heat treatment apparatus as described above of which the replacing means includes a means for blowing inert gas into the treatment chamber.

[0018]

The heat treatment apparatus of the present invention is the heat treatment apparatus as described above, wherein the blowout of inert gas by the blowing means is controlled in accordance with the temperature of the substrate.

[0019]

The heat treatment apparatus of the present invention is a treatment system comprising: the heat treatment apparatus as described above; and a carrier apparatus disposed in the treatment chamber containing inert gas atmosphere for carrying the substrate in/out, wherein said carrying apparatus includes a holding and cooling plate for holding and cooling the substrate, and adjusting and supporting pins disposed adjustably in height on the holding and cooling plate for supporting the substrate to be apart from the holding and cooling plate.

[0020]

In the present invention, when a substrate coated with a coating solution which oxidizes at high temperatures is heat-treated, a gas concentration such as an oxygen

concentration or the like of a heat treatment atmosphere in which heat treatment is performed is controlled so that, for example, the treatment atmosphere is replace with inert gas. Thereby, the substrate can be heat-treated, with the oxidization of the coating solution being controlled.

[0021]

Specifically, in a state that the substrate is supported by support pins and apart from a surface of the holding and heating member, the atmosphere in the treatment chamber is replaced with the inert gas. The support pins withdraw, thereby the substrate abuts on the surface of the holding and heating member to be heat-treated. After completing the heat treatment, the substrate is separated from the surface of the holding and heating member by projecting the support pins. Further, after the passage of a predetermined time or when the temperature of the substrate is lowered than a predetermined value, a lid body is opened to expose the inside of the treatment chamber to the air. The above structure easily enables replacement with inert gas, heat treatment after the replacement, and cooling after the heat treatment. If replacement with inert gas and heat treatment after the replacement are intended to be realized by controlling the temperature of the holding and heating member, temperature-controlling is difficult and especially it is difficult that the temperature is returned to the original value (e.g., room temperature) to perform the next replacement after heating.

[0022]

Moreover, in the treatment system of the present invention, adjusting and supporting pins which are replaced on the holding and cooling plate of the carrying apparatus can be adjusted in height, therefore a very simple structure enables a fine adjustment to be easily performed for appropriate cooling.

[0023]

[Detailed Description of the Preferred Embodiments]

Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings.

Fig. 1 is a plane view of a film-forming system according to an embodiment of the present invention, Fig. 2 is a front view of the film-forming system shown in Fig. 1,

and Fig. 3 is a rear view of the film-forming system shown in Fig. 1.

[0024]

As shown in Fig. 1 to Fig. 3, a film-forming system 1 has a configuration in which a cassette station 2 and a process station 3 are united. In the cassette station 2, a plurality of wafers W per cassette, for example, 25 wafers are carried in the film-forming system 1 from the outside and carried out of the film-forming system 1 to the outside. Additionally, the wafers W are carried into/out of the cassette C. In the process station 3, various kinds of treatment units are multi-tiered at designated positions and each treatment unit gives a predetermined treatment to the wafers W one by one in a film-forming process.

[0025]

In the cassette station 2, as shown in Fig. 1, a plurality of, for example, four cassettes C are mounted in a line in an X-direction (a vertical direction in Fig. 1), with the respective ways in/out for the wafers W opening to the process station 3 side at positions of positioning projections 10a on a cassettes mounting table 10. A wafer carrier 15, which can move in the direction of the disposition of the cassettes C (the X-direction) and in the direction of the disposition of the wafers W stored in the cassette C (a Z-direction; a vertical direction), is movable along a carrier path 15a to be selectively accessible to each cassette C.

[0026]

The wafer carrier 15 is also rotatable in a θ-direction and accessible to an alignment unit (ALIM) and an extension unit (EXT) included in multi-tiered units of a third treatment unit group G3 on the process station 3 side as described later.

[0027]

In the process station 3, as shown in Fig. 1, a carrier unit 20 with a vertical carrier system is placed in a center portion thereof. Around the carrier unit 20, one of various kinds of treatment units are multi-tiered to compose a treatment unit group. In the film-forming system 1, four treatment unit groups G1, G2, G3, and G4 can be arranged. The first and second treatment unit groups G1 and G2 are arranged on the front side of the system, the third treatment unit group G3 is disposed adjacent to the cassette station 2, and the fourth treatment unit group G4 is disposed at the position facing to the third treatment unit group G3 across the carrier unit 20. The carrier unit 20 is rotatable in the θ-direction and

movable in the Z-direction, and can receive/send the wafer W from/to each treatment unit.

[0028]

As shown in Fig. 2, in the first treatment unit group G1, two spinner-type supply units 4 which mount and rotate the wafer W on a spin chuck in a cup CP to supply a predetermined treatment solution onto a rotational center of the wafer W from a supply nozzle (not shown), are two-tiered. Also in the second treatment unit group G2 similarly to the first treatment unit group G1, two spinner-type supply units 4 are two-tiered. The predetermined treatment solution is a coating solution which oxidizes at high temperatures, more specifically, an organic coating solution such as plastic or the like can be given as an example.

[0029]

As shown in Fig. 2, high efficiency filters 23 such as a ULPA filter are provided for the aforesaid zones (the cassette station 2 and the process station 3) respectively at the top of the film-forming system 1. Particles and organic elements are collected and removed from air which is supplied from the upstream side of the high efficiency filters 23 while the air passing the high efficiency filters 23. Accordingly, through the high efficiency filter 23, a down flow of clean air from the upper part is supplied in a direction shown by a solid line with an arrow or a dotted line with an arrow to the aforesaid cassettes mounting table 10, the carrier path 15a of the wafer carrier 15, the first and second treatment unit groups G1 and G2, and the third, fourth and fifth treatment unit groups G3, G4, and G5.

[0030]

In the third treatment unit group G3, as shown in Fig. 3, an oven-type treatment unit for mounting the wafer W on the mounting table and performing a predetermined treatment, for example, the alignment unit (ALIM) for positioning, the extension unit (EXT), and heat treatment units (BAKE) for heat-treating are eight-tiered in total.

[0031]

In the fourth treatment unit group G4, an oven-type treatment unit for mounting the wafer W on the mounting table and performing a predetermined treatment, for example, heat treatment units (BAKE) for heat-treating are eight-tiered in total.

[0032]

As described above, the unit group for supplying a coating solution and that for heat-treating are separated from each other, thereby reducing thermal interference from the heat treatment unit (BAKE) to the supply unit 4. Specifically, in the embodiment, the temperature of heat treatment in the heat treatment unit (BAKE) reaches about 400℃, so that the reduction of thermal interference is useful. Meanwhile, respective unit groups are multi-tiered so as to be gathered, thereby down-sizing the system and improving treatment efficiency. Specifically, making various kinds of units and gathering the units in one body as has been described enables a multi-tiered film to be efficiently formed.

[0033]

Figs. 4 and 5 are front views and Fig. 6 is a plane view of the heat treatment unit (BAKE). Fig. 4 shows a state where support pins have withdrawn into a hot plate as described later, and Fig. 5 shows a state where the support pins are projecting from the hot plate.

As shown in Fig. 4 to Fig. 6, a hot-plate 31 for heat-treating a wafer W is placed near the center of the heat treatment unit (BAKE). A hot wire, for example, is buried in the hot plate 31 so that the surface-temperature of the hot plate 31 becomes, for example, approximately 400℃ when heat-treating. The hot plate 31 is provided with a plurality of, for example, three support pins 32 in a manner to appear and disappear for sending and receiving the wafer W, so that the support pins 32 are vertically moved by a hoisting and lowering mechanism 33 which is placed on the rear face of the hot plate 31.

[0034]

Around the hot plate 31, an N_2 gas blowing duct 34 is provided in a manner to surround the hot plate 31. The N_2 gas blowing duct 34 is provided with a number of blowing nozzles 35, from which N_2 gas is blown into the unit. In place of N_2 gas, other inert gas such as Ar gas or the like can be used.

[0035]

A lid body 36 is placed above the hot plate 31 to form an airtight space between the lid body 36 and the hot plate 31. The lid body 36 is vertically movable by a hoisting and lowering mechanism (not shown). Further, the lid body 36 is structured

to incline upward to the center thereof and an exhaust port 37 is provided at the center of the lid body 36. The exhaust port 37 is connected to, for example, an exhaust apparatus (not shown) such as a vacuum pump or the like.

[0036]

As has been described, the N_2 gas blowing duct 34 is disposed at the bottom part, the exhaust port 37 is disposed at the top part, and further the exhaust port 37 is structured as above, thereby efficiently replacing the inside of the heat treatment unit (BAKE) with N_2 gas.

[0037]

Next, actions in the heat treatment unit (BAKE) structured as above will be described hereinafter.

Fig. 7 represents changes with the passage of time of the temperature of the wafer W in the heat treatment unit (BAKE) and an oxygen concentration in the unit.

First, the wafer W coated with a coating solution is sent from the carrier unit 20 onto the support pins 32 in a state where the support pins 32 are projecting from the hot plate 31 and the lid body 36 opens. Thereafter, the gas in the unit is discharged from the exhaust port 37 while N_2 gas is blown from the blowing nozzles 35 of the N_2 gas blowing duct 34, as shown in Fig. 5, in a state where the lid body 36 closes and the support pins 32 projecting from the hot plate 31 support the wafer W. Thereby the inside of the unit is replaced with N_2 gas without the wafer W being heated to high temperatures (a period of Fig. 7(1)). The period of (1) is preferably about 30 second, for example.

[0038]

Next, as shown in Fig. 4, the support pin 32 withdraw into the hot plate 31, which allows the wafer W to abut on a surface of the hot plate 31 (a period of Fig. 7(2)). The period of (2) is preferably about 70 seconds, for example. Thereby, the wafer W is heat-treated at approximately 400℃. However, since the inside of the unit is filled with N_2 atmosphere at that time, the coating solution applied to the surface of the wafer W does not oxidize.

[0039]

Next, as shown in Fig. 5, the support pins 32 project from the hot plate 31,

which allows the wafer W to be separated from the surface of the hot plate 31. The lid body stands closed, for example, for about ten seconds. Thereby, the temperature of the wafer W can be lowered to a value at which the coated film does not oxidize in N_2 atmosphere. Thereafter, the lid body 36 is opened to expose the inside of the treatment chamber to the air (a period of Fig. 7(3)). The period of (3) is preferably approximately 30 second, for example. Sequentially, the wafer W is carried out of the unit by the carrier unit 20.

[0040]

As has been described, according to the embodiment, when the wafer W coated with the coating solution is heat-treated, the atmosphere in which heat treatment is performed is replaced with N_2 gas. Therefore, the wafer W can be heat-treated, while the oxidization of the coating solution is controlled.

[0041]

In the above embodiment, atmospheric-opening is performed after a predetermined time. Alternatively, for example, a means for measuring temperature such as a thermo-couple (for instance, provided in the hot plate) to measure the temperature of the wafer W to be heat-treated may be provided so that exposure to the air may be performed when the temperature of the wafer W becomes lower than a predetermined value. Thereby, exposure to the air can be performed after the temperature of the wafer W has fallen thoroughly, resulting in more efficiently preventing the coated film from oxidizing. At that time, the blowout of N_2 gas which is blown from the blowing nozzles 35 of the N_2 gas blowing duct 34 may be controlled. For example, as shown in Fig. 8, an opening and closing valve 82 is provided between the N_2 gas blowing duct 34 and an N_2 gas source 81 so as to be opening-and-closing-controlled by a control section 83. The opening and closing valve 82 is opened to blow N_2 gas from the blowing nozzles 35 of the N_2 gas blowing duct 34 until the temperature of the wafer W becomes lower than a predetermined value based on the measured results by the means for measuring temperature. When the temperature of the wafer W has become lower than the predetermined value, the opening and closing valve 82 is closed to stop the blowout of N_2 gas from the blowing nozzles 35 of the N_2 gas blowing duct 34.

[0042]

Next, another embodiment of the present invention will be described hereinafter.

Fig. 9 is a front view showing the structure of a treatment system according to the embodiment.

As shown in Fig. 9, in the heat treatment unit (BAKE) shown in Fig. 4 to Fig. 6, disposed are a chamber 41 and a carrying apparatus 42 for carrying the wafer into/out of the heat treatment unit (BAKE) or the like. The inside of the heat treatment unit (BAKE) is filled with an atmosphere of inert gas such as N_2 gas, Ar gas, or the like. Thus, the coated film on the wafer W can be prevented from oxidizing while it is carried.

[0043]

The carrying apparatus 42 has a base 43, on which a holding and cooling plate 44 for mounting and cooling the wafer W is placed. The holding and cooling plate 44 is movable forward and rearward to and from the heat treatment unit (BAKE) by a driving mechanism (not shown). Further, a cooling mechanism (not shown) is embedded in the holding and cooling plate 44, so that the wafer W which is held by the holding and cooling plate 44 after being heat-treated by the heat treatment unit (BAKE) is rapidly cooled.

[0044]

Here, a plurality of, for example, three adjusting and supporting pins 45 are arranged on a surface of the holding and cooling plate 44 so as to support the wafer W to be parted from the holding and cooling plate 44. Each adjusting and supporting pin 45 is screwed, as shown in Fig. 10, to the holding and cooling plate 44. Thereby, the space between the surface of the holding and cooling plate 44 and the adjusting and supporting pins 45 can be adjusted. Accordingly, a fine adjustment for an appropriate cooling can be easily performed with a very simple structure. For example, there is a case that a temperature-falling rate at the time of cooling is required to be changed corresponding to the film-thickness of the wafer W. In this embodiment, the space between the surface of the holding and cooling plate 44 and the adjusting and supporting pins 45 is adjusted, thereby allowing the temperature-falling rate ((4) of Fig. 11) to become changeable as shown in Fig. 11.

[0045]

In addition, when the treatment system as shown in Fig. 9 is applied to the system 1 shown in Fig. 1, the treatment system as shown in Fig. 9 is included in the treatment unit group G3 or G4. In this case, the treatment system as shown in Fig. 9 can be mixed with the heat treatment unit (BAKE) shown in Fig. 4 to Fig. 6. Specifically, in this case, the treatment system as shown in Fig. 1 is preferably included in the treatment unit group G3. The reason is that, if the treatment system as shown in Fig. 9 is included in the treatment unit group G4, an interference with the treatment unit group G5 occurs.

[0046]

Further, the example where the semiconductor wafer is used for heat treatment has been described and the present invention, not limited to the example, can also be employed in the case where an LCD substrate is used.

[0047]

[Advantages of the Invention]

As has been described, according to the present invention, when a substrate coated with a coating solution which oxidizes at high temperatures is heat-treated, a gas concentration of a heat treatment atmosphere is controlled so that the substrate can be heat-treated, while the oxidization of the coating solution is controlled.

[0048]

According to the present invention, in a state that the substrate is supported by support pins and apart from the surface of the holding and heating member, the atmosphere in the treatment chamber is replaced with inert gas. The support pins withdraw, thereby the substrate abuts on the surface of the holding and heating member to be heat-treated. After completing the heat treatment, the substrate is separated from the surface of the holding and heating member by projecting the support pins. Further, after the passage of a predetermined time, the lid body is opened to expose the inside of the treatment chamber to the air. The above structure easily enables replacement of the heat treatment atmosphere with inert gas, heat treatment of the wafer in the replaced inert gas atmosphere, and cooling the heat-treated wafer.

[0049]

Further, according to the present invention, the adjusting and supporting pins placed above the holding and cooling plate of the carrier unit is adjustable in height, thereby enabling a fine adjustment to be easily performed for appropriate cooling.

[Brief Description of the Drawings]

[Fig. 1]

A plane view of a film-forming system according to an embodiment of the present invention.

[Fig. 2]

A front view of the film-forming system shown in Fig. 1.

[Fig. 3]

A rear view of the film-forming system shown in Fig. 1.

[Fig. 4]

A front view of a heat treatment unit shown in Fig. 1.

[Fig. 5]

A rear view of the heat treatment unit shown in Fig. 1.

[Fig. 6]

A plane view of the heat treatment unit shown in Figs. 4 and 5.

[Fig. 7]

A diagram representing changes with the passage of time of the temperature of a wafer W in the heat treatment unit shown in Fig. 6 and an oxygen concentration in the unit.

[Fig. 8]

A block diagram showing a modification of the heat treatment unit of the embodiment.

[Fig. 9]

A front view of a structure of a treatment system according to another embodiment of the present invention.

[Fig. 10]

A view showing an example of adjusting and supporting pins shown in Fig. 9.

[Fig. 11]

A view showing an example of varying a temperature drop rate.

[Fig. 12]

A plane view of a film-forming system of another embodiment according to the present invention.

[Reference Characters]

31: Hot plate

32: Support pin

34: N_2 gas blowing duct

35: Blowing nozzle

36: Lid body

41: Chamber

42: Carrier unit

44: Holding and cooling plate

45: Adjusting and supporting pin

BAKE: Heat treatment unit

W: Wafer